Struggling on opposite hemispheres: NGRIP and EPICA 1996-2006

Frank Wilhelms

Laurent Augustin

Sigfus Johnsen

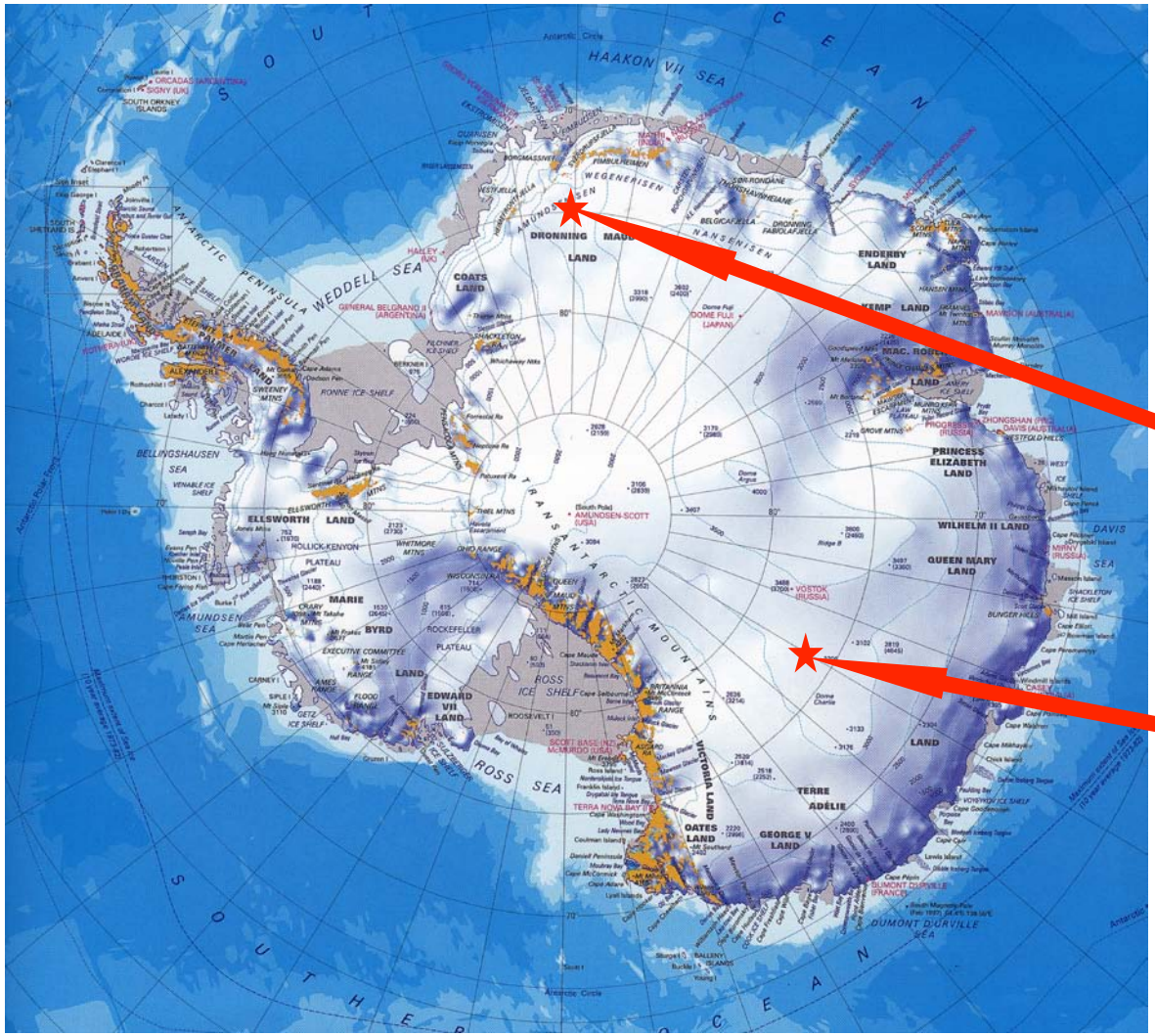
Steffen Bo Hansen, Niels Gundstrup, Jakob Schwander, Heinrich Rufli + many more

After the great success at GRIP …

… it was obvious that the momentum had to be kept and during an ESF workshop on Crête …

… the European Project for Ice Coring in Antarctica (EPICA) was initiated

European Project for Ice Corring in Antarctica
EPICA



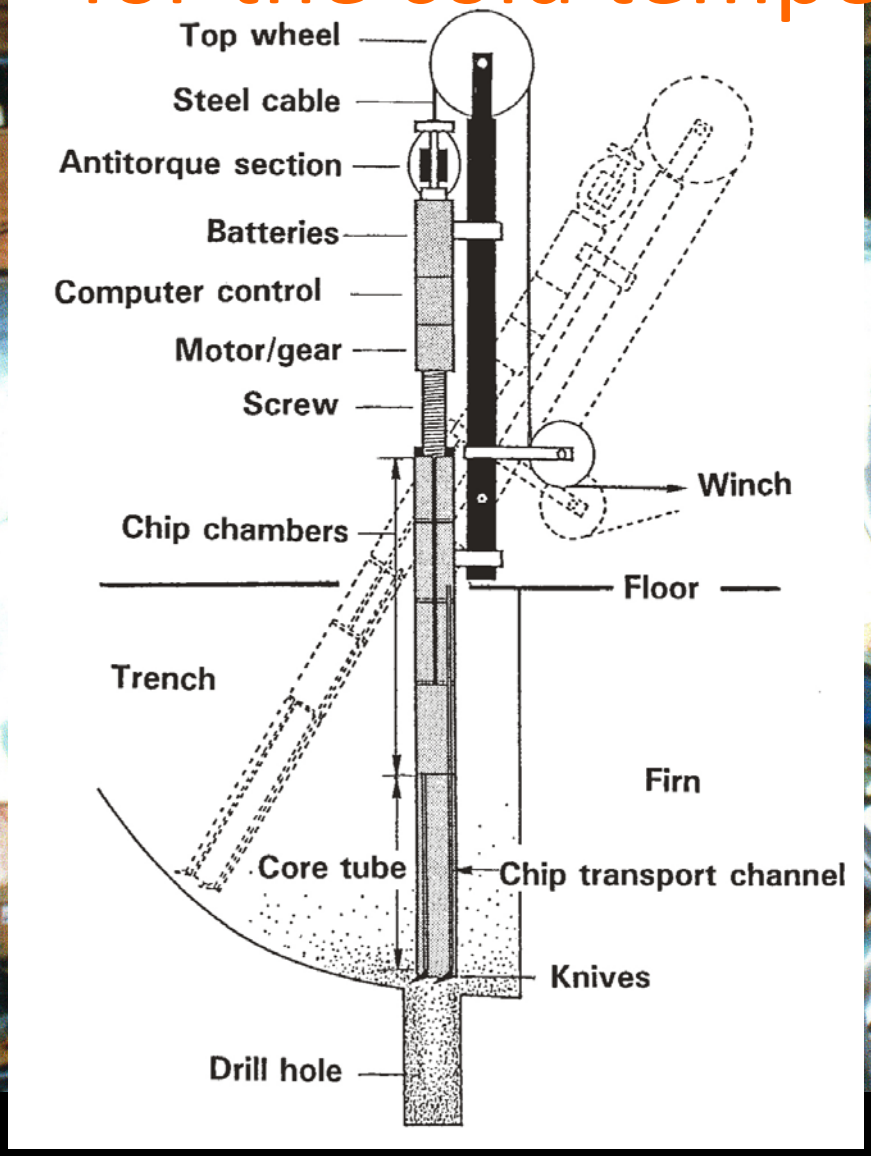
Kohnen station
75° South, 0° East
Elevation: 2892 m
Ice thickness: 2755m

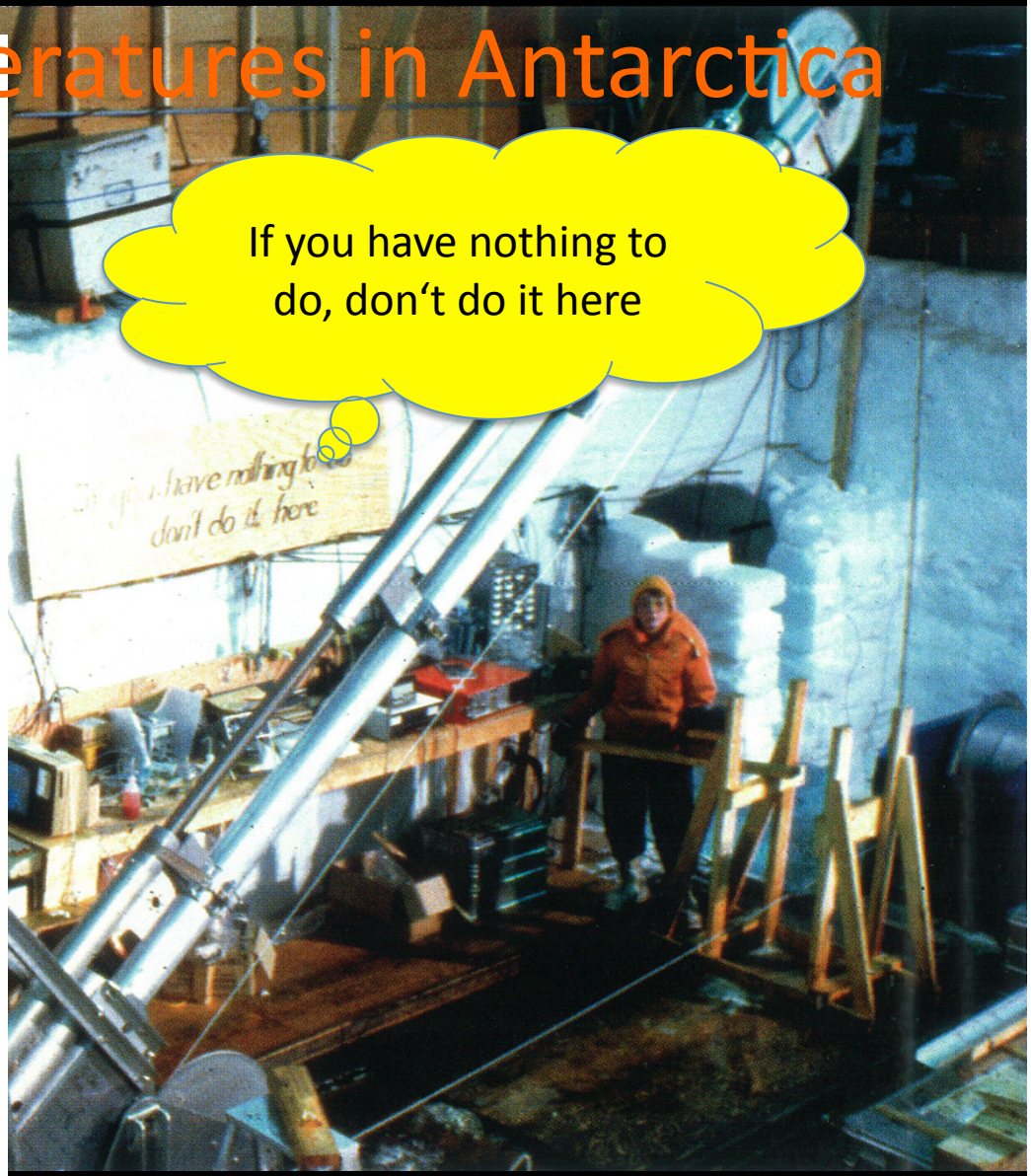
Accumulation : 64 kg/m^2/yr
Average temperature : -44° C

Concordia station
75° South, 124° East
Elevation: 3250m
Ice thickness: 3280m

Accumulation : 25 kg/m^2/y
Average temperature : -55° C

The ISTUK drill was not believed suitable for the cold temperatures in Antarctica





The GRIP / GISP2 Eemian problem

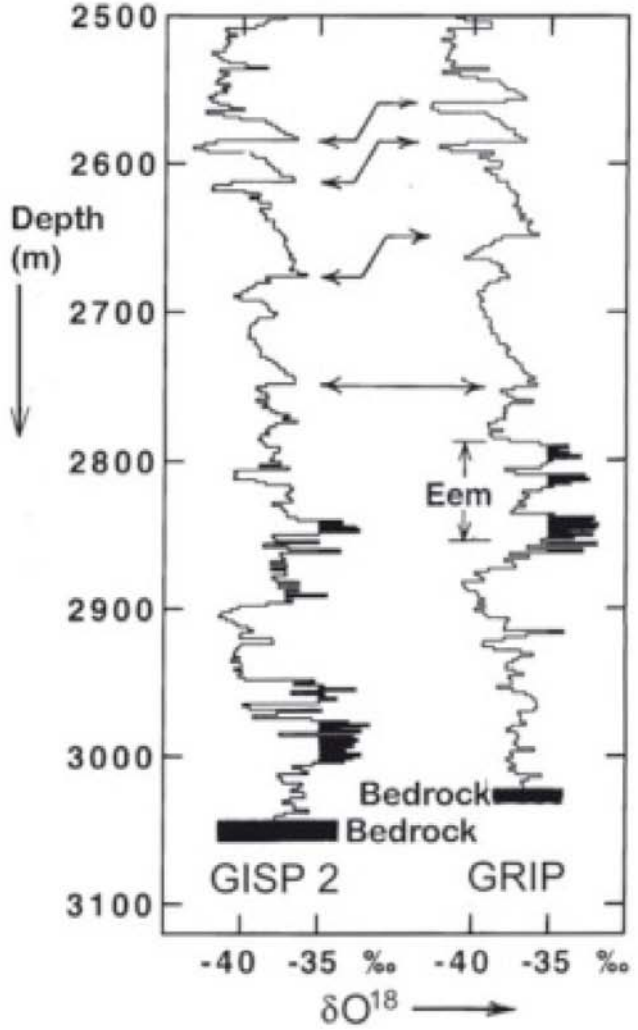
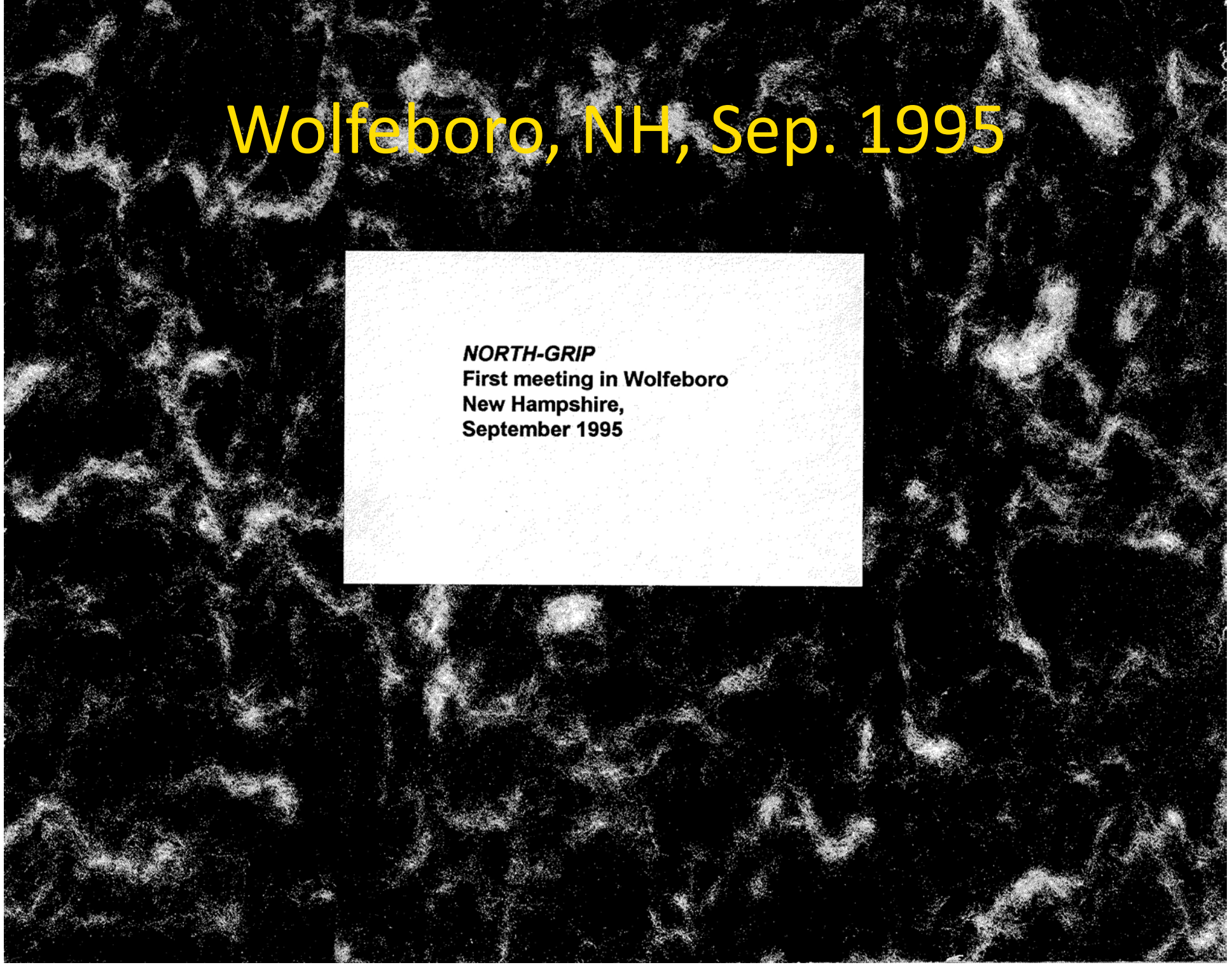
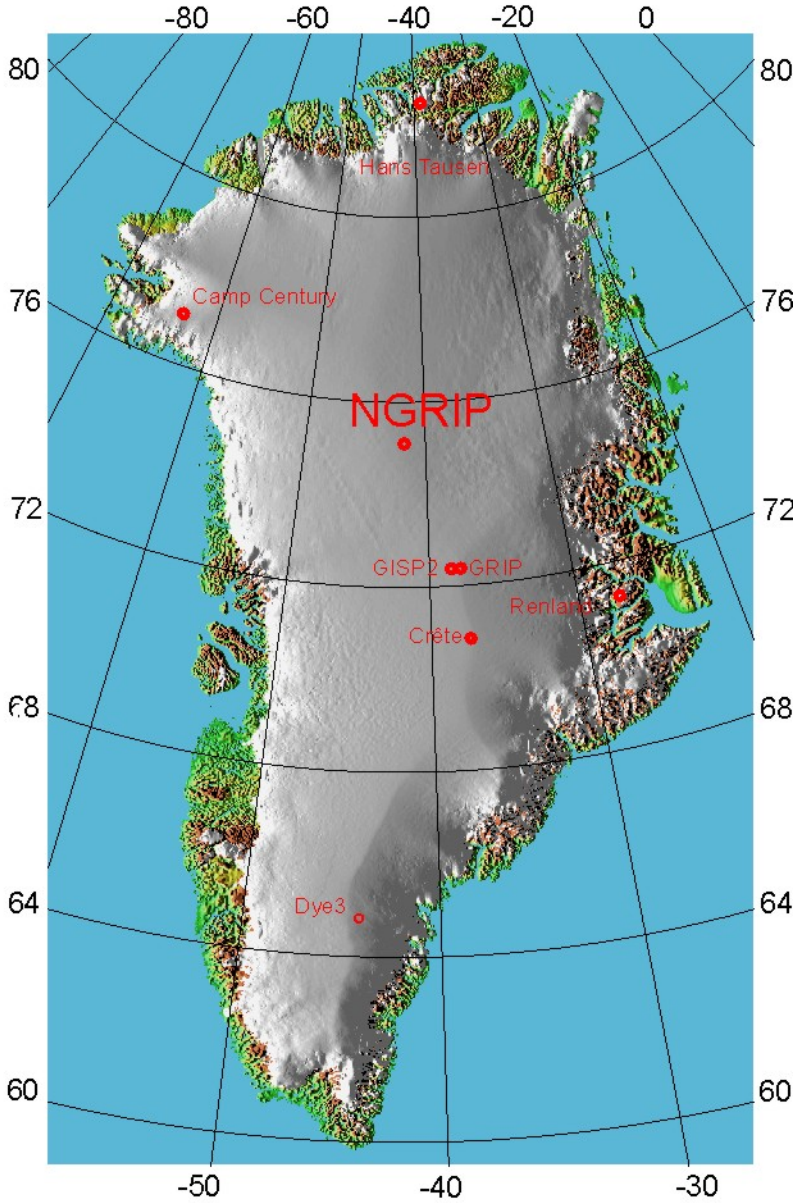


Fig. 13.4 *δ profiles along the deepest parts of the GRIP ice core (to the right) and the American GISP2 core (to the left). Down to a depth of 2750 m the two profiles are essentially identical, but they are different in ice from the Eem period. The layer sequence is disturbed in the GISP2 core. Is this also the case for the GRIP core?*


Wolfeboro, NH, Sep. 1995

Wolfeboro, NH, Sep. 1995



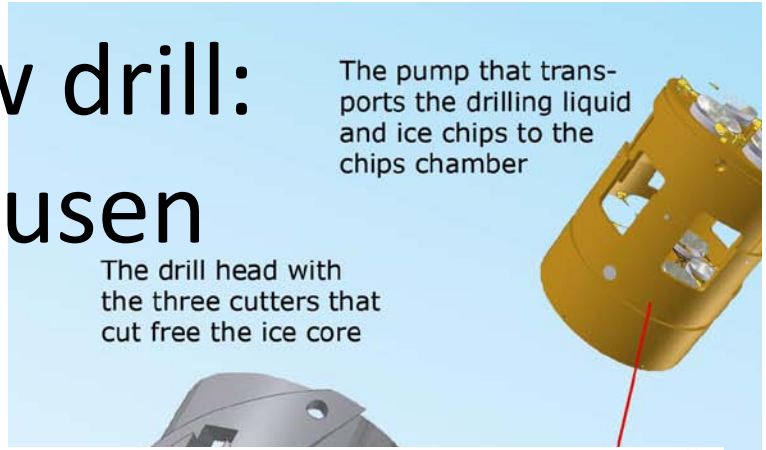


http://www.gfy.ku.dk/~www-glac/ngrip/

Hans Tausen (HT) drill:

Dry and wet drilling with the Suzuki booster

The new drill: Hans Tausen drill



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The Hans Tausen drill: design, performance, further developments and some lessons learned

Sigfús J. JOHNSEN,[1] Steffen Bo HANSEN,[1] Simon G. SHELDON,[1]
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Thorsteinn THORSTEINSSON,[8] Frank WILHELMS,[9] Victor ZAGORODNOV[10]

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[2]*Laboratoire de Glaciologie et Géophysique de l'Environnement du CNRS (associé à l'Université Joseph Fourier–Grenoble I), 54 rue Molière, BP 96, 38402 Saint-Martin-d'Hères Cedex, France*
[3]*Physics Institute, University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland*
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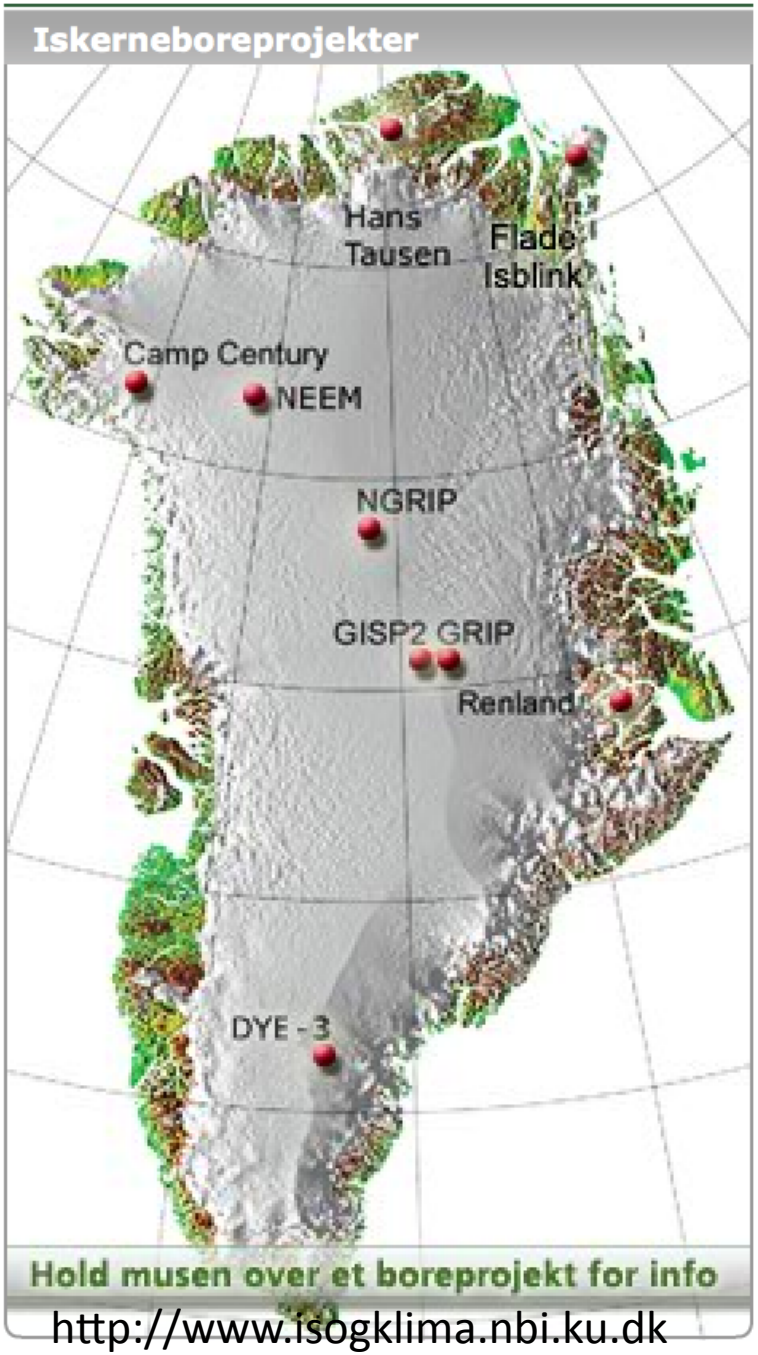
[8]*National Energy Authority, Grensásvegur 8, IS-108 Reykjavík, Iceland*
[9]*Alfred Wegener Institute for Polar and Marine Research, PO Box 120161, D-27515 Bremerhaven, Germany*
[10]*Byrd Polar Research Center, The Ohio State University, 1090 Carmack Road, Columbus, OH 43210-1002, USA*

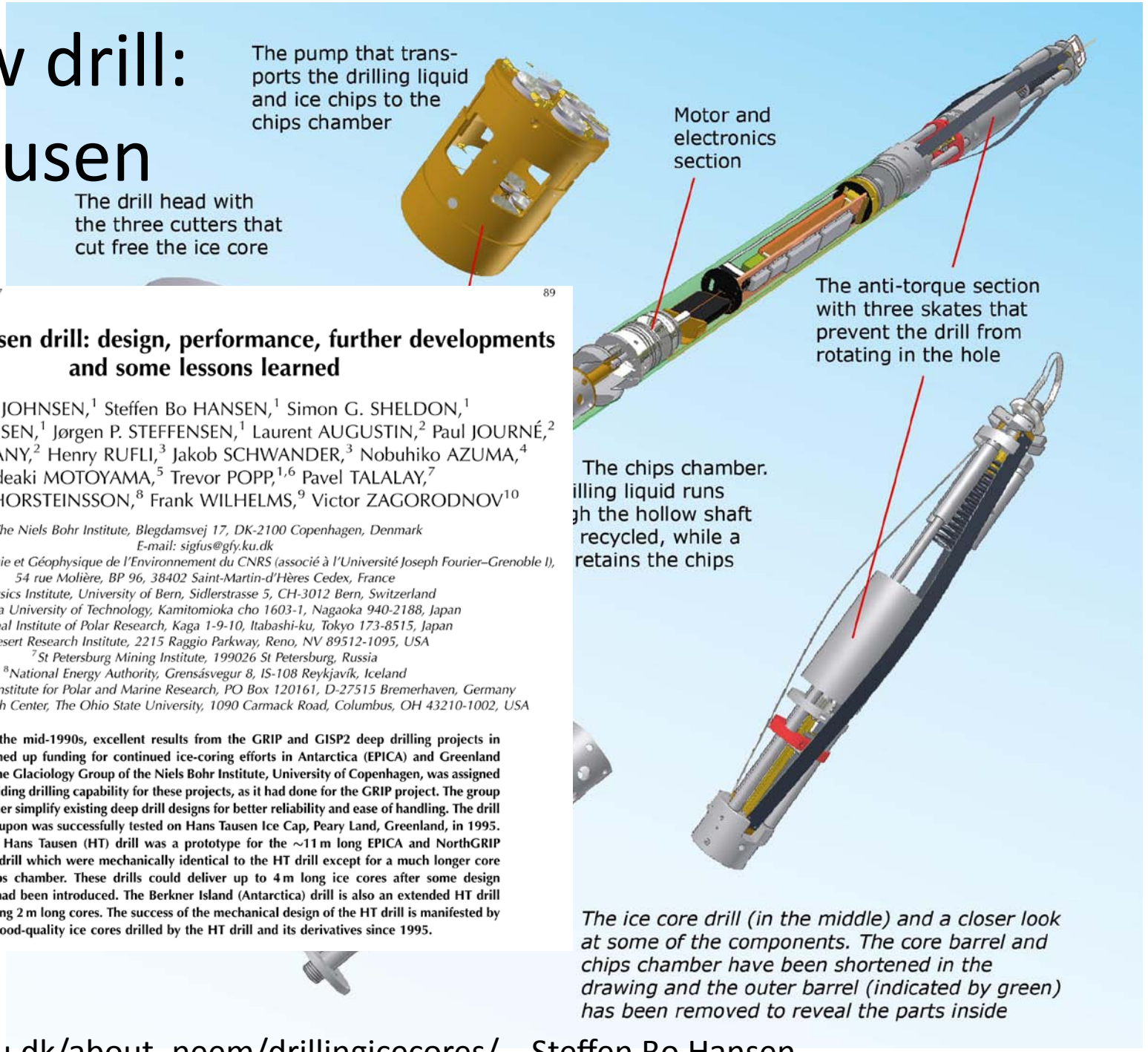
ABSTRACT. In the mid-1990s, excellent results from the GRIP and GISP2 deep drilling projects in Greenland opened up funding for continued ice-coring efforts in Antarctica (EPICA) and Greenland (NorthGRIP). The Glaciology Group of the Niels Bohr Institute, University of Copenhagen, was assigned the task of providing drilling capability for these projects, as it had done for the GRIP project. The group decided to further simplify existing deep drill designs for better reliability and ease of handling. The drill design decided upon was successfully tested on Hans Tausen Ice Cap, Peary Land, Greenland, in 1995. The 5.0 m long Hans Tausen (HT) drill was a prototype for the ~11 m long EPICA and NorthGRIP versions of the drill which were mechanically identical to the HT drill except for a much longer core barrel and chips chamber. These drills could deliver up to 4 m long ice cores after some design improvements had been introduced. The Berkner Island (Antarctica) drill is also an extended HT drill capable of drilling 2 m long cores. The success of the mechanical design of the HT drill is manifested by over 12 km of good-quality ice cores drilled by the HT drill and its derivatives since 1995.



http://www.isogklima.nbi.ku.dk

http://neem.nbi.ku.dk/about_neem/drillingicecores/ Steffen Bo Hansen

The new drill: Hans Tausen drill



The ice core drill (in the middle) and a closer look at some of the components. The core barrel and chips chamber have been shortened in the drawing and the outer barrel (indicated by green) has been removed to reveal the parts inside

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http://neem.nbi.ku.dk/about_neem/drillingicecores/ Steffen Bo Hansen

The cuttings struck

FIELD SEASON REPORT 1

Prepared by the NGRIP Operation

for

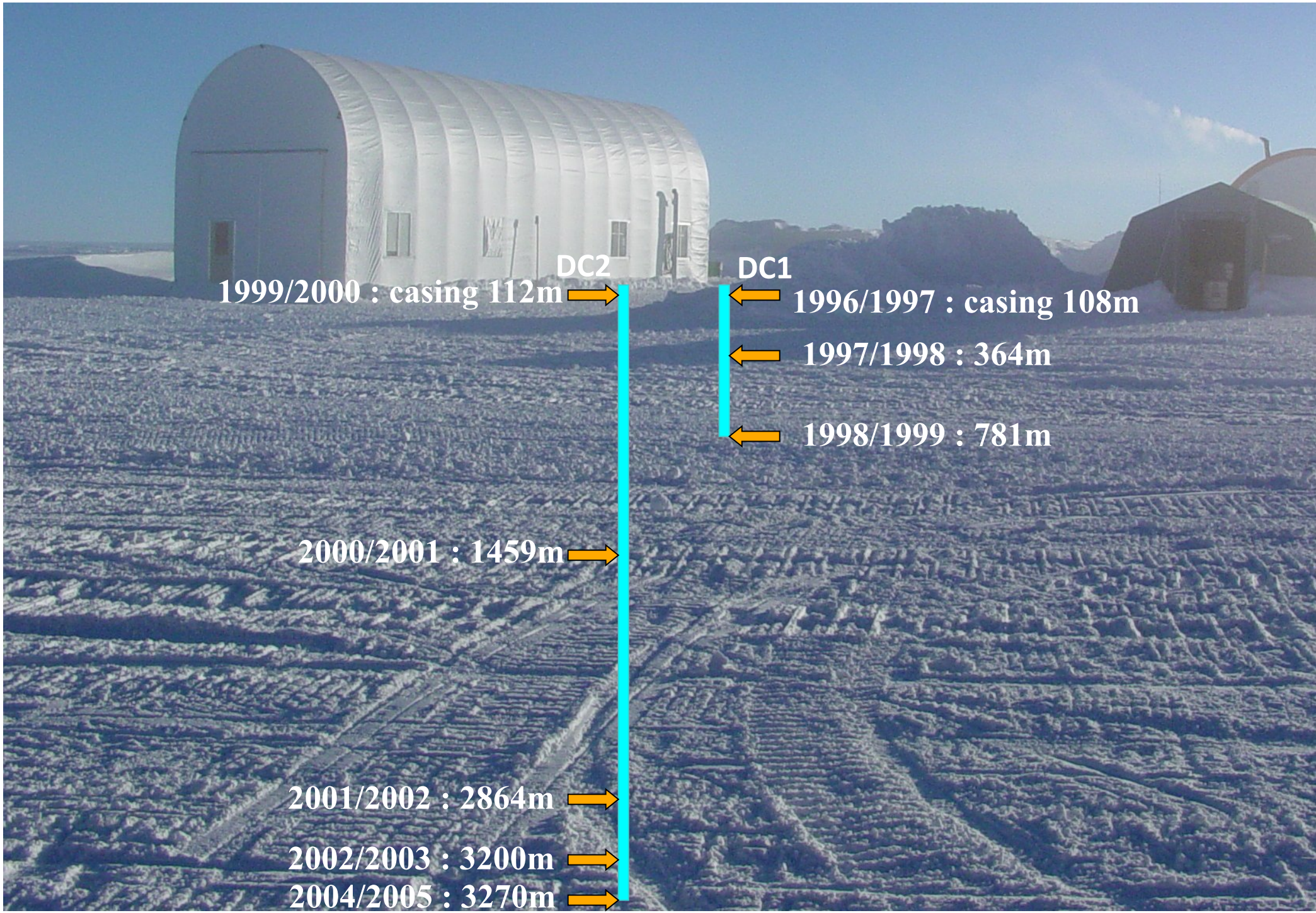
The NGRIP 1997 participants, The Greenlandic and Danis and the NGRIP and EPICA Steering Bodies

Paris, October 20-21, 1997

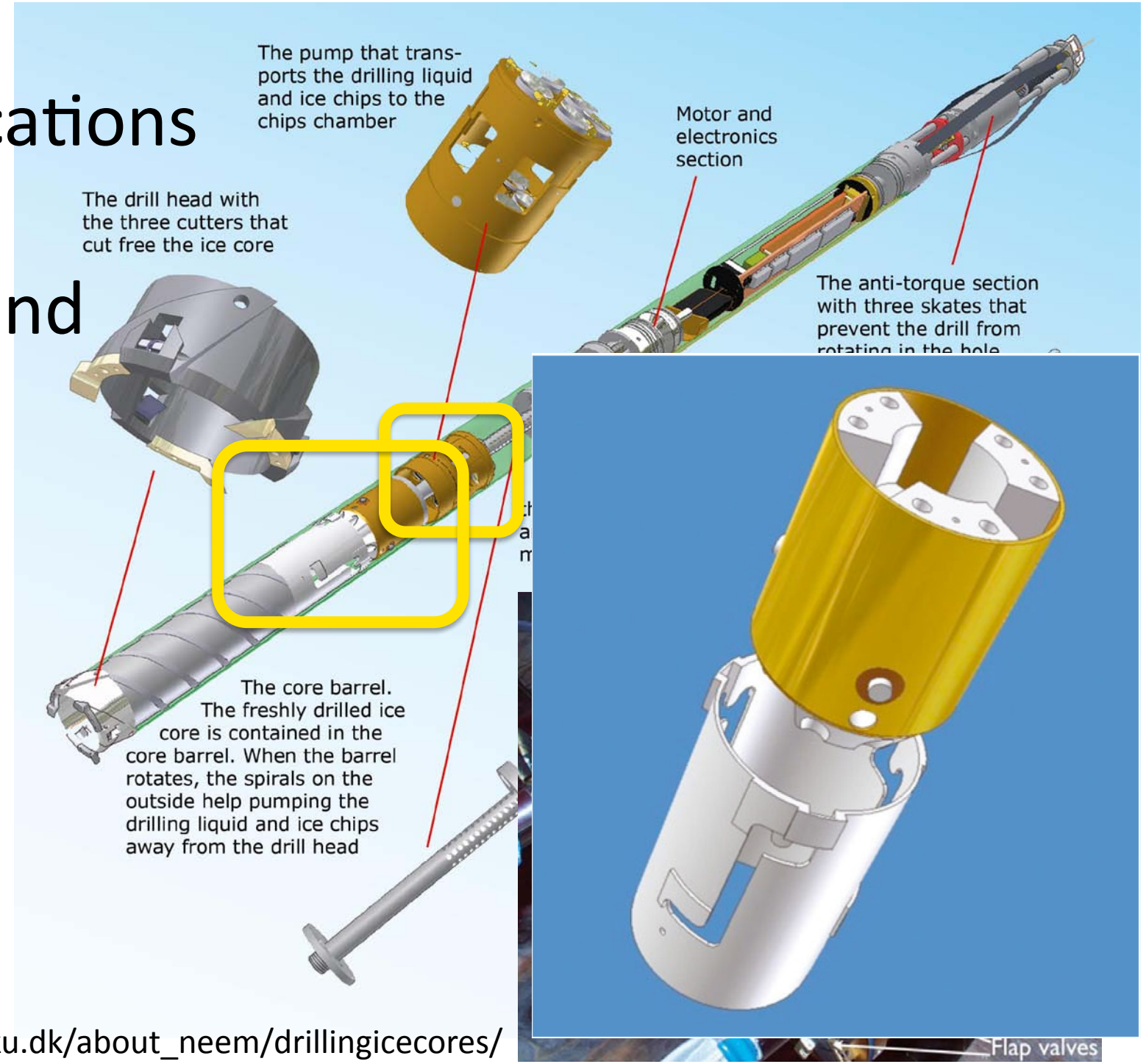
NGRIP 1997 Penetration

970718	Friday. Pitch increased to 4,5mm. drilling stable.
970719	Saturday. Temperature profile in shallow hole.
970720	Sunday. -14 degC in science trench. Drilling stable until the drill gets stuck.
970722	Tuesday. Cable tension increased to 2000kp.
970723	Wednesday. GPS pole positioned in 99m hole.
970724	Thursday. T. O. arrived and departed. Shallow hole started.
970725	Friday. T.O. arrived and departed. Processing of second shallow core started.
970726	Saturday. AWI sledges placed 500 from camp. First 10*15 weatherport down.
970729	Tuesday. Shallow drilling S2 terminated at 151,5m. Processed to 138.7m. Weatherports packed, work on tower house.
970730	Wednesday. Tower house finished.
970731	Thursday. Window in drill trench roof lifted. 20' dome tent lifted 1m. Sensitivity of strain guage transducer measuring cable load reduced a factor of 2.4
970801	Friday. Roof exit of elevator lifted 1,22m.
970804	Monday. Camp retro, 16 pax.
970808	Friday. SFJ office closed.
970926	Friday. 2 pax to REK, 3 to AEY
970927	Saturday. 3 pax to NGP via CNP and Summit. Drill trench opened
970928	Sunday. 5 torpedoes attached to cable and down the hole. Seems to hang on cable 300m down.
970929	Monday. 125l of glycol at 130m, 130l of densifier at 100m..

DOME CONCORDIA station and summer camp
3250m elevation

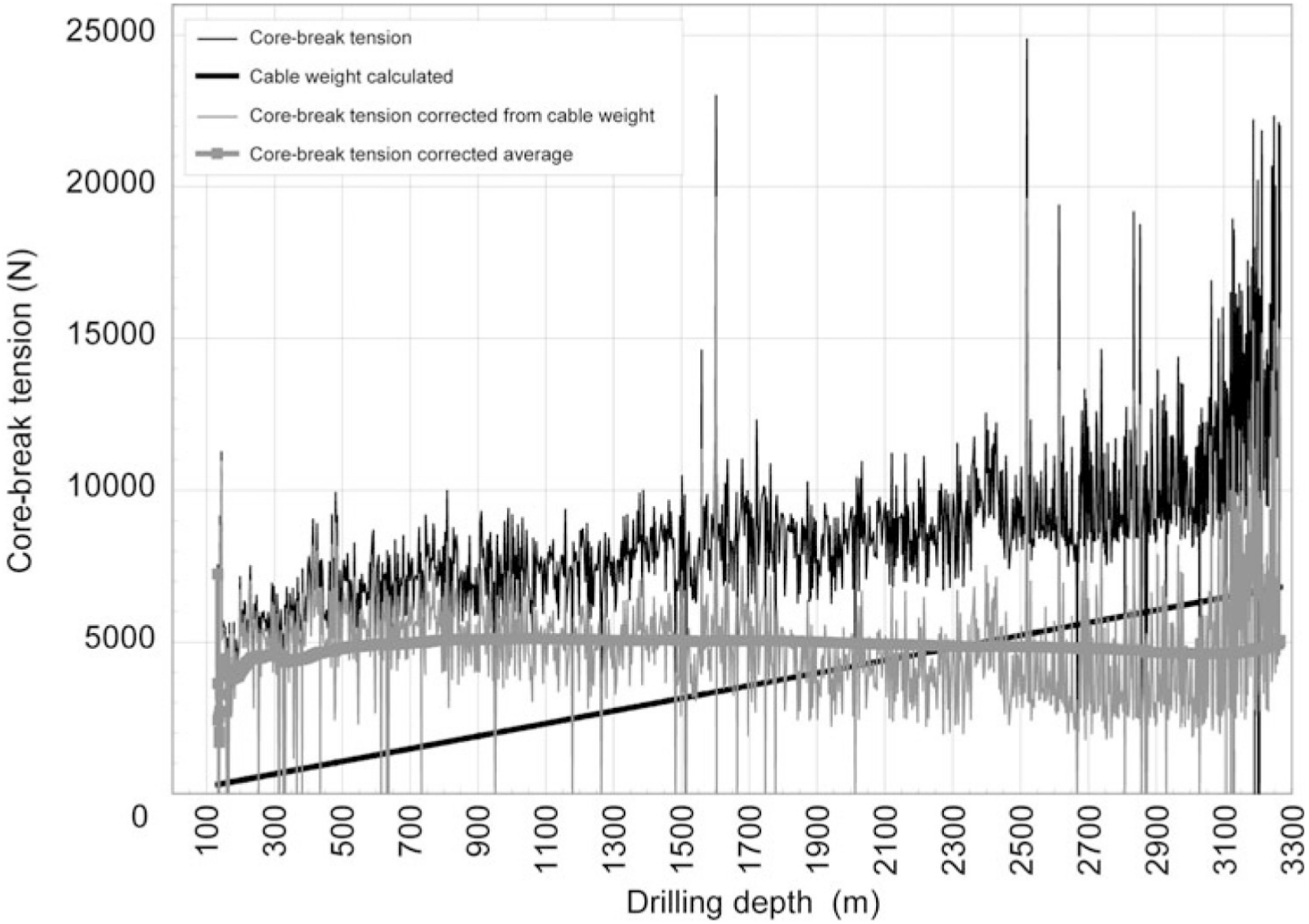

DC2
DC1
1999/2000 : casing 112m
1996/1997 : casing 108m
1997/1998 : 364m
1998/1999 : 781m
2000/2001 : 1459m
2001/2002 : 2864m
2002/2003 : 3200m
2004/2005 : 3270m

Modifications to drill: Pump and Super-banger

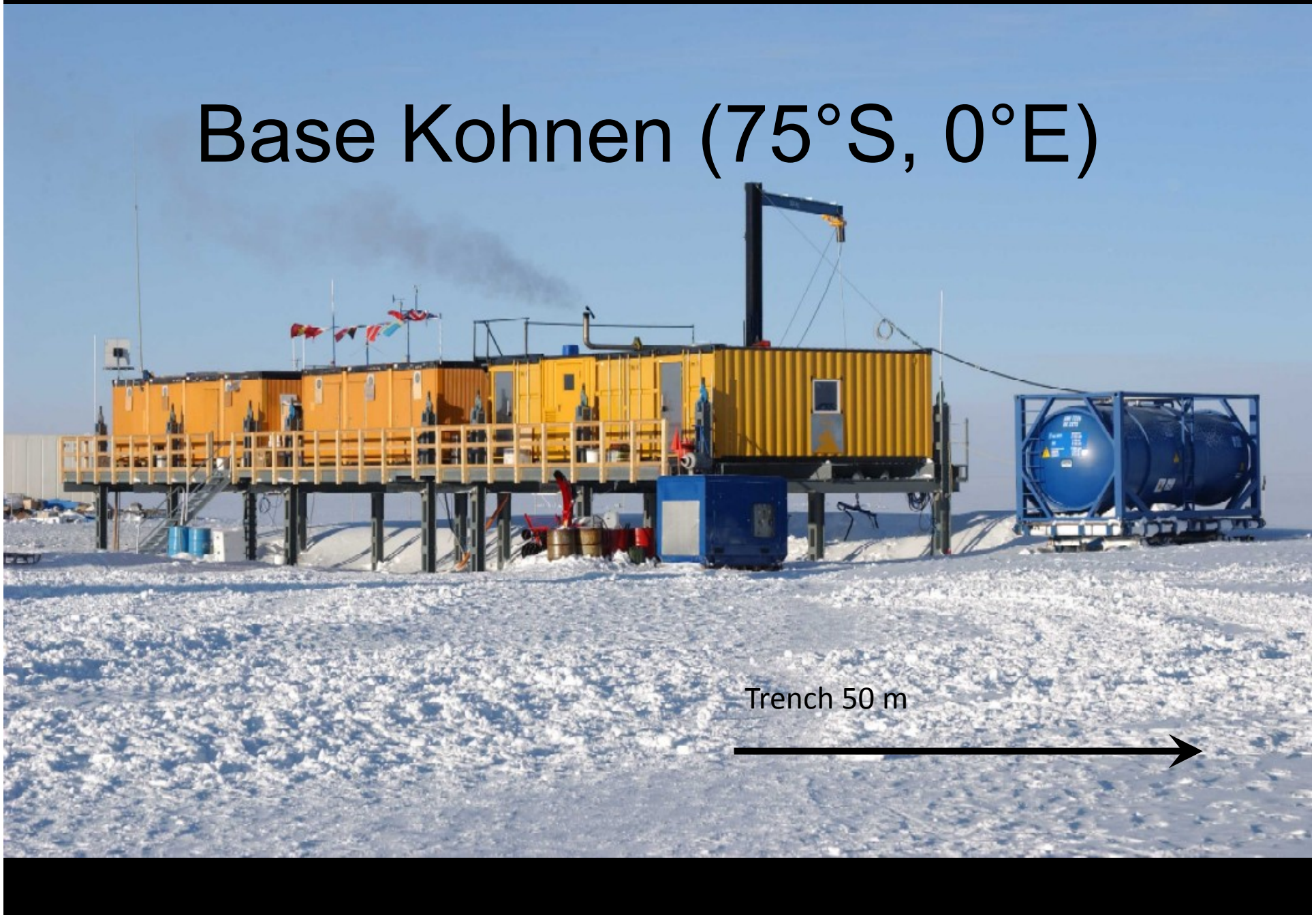


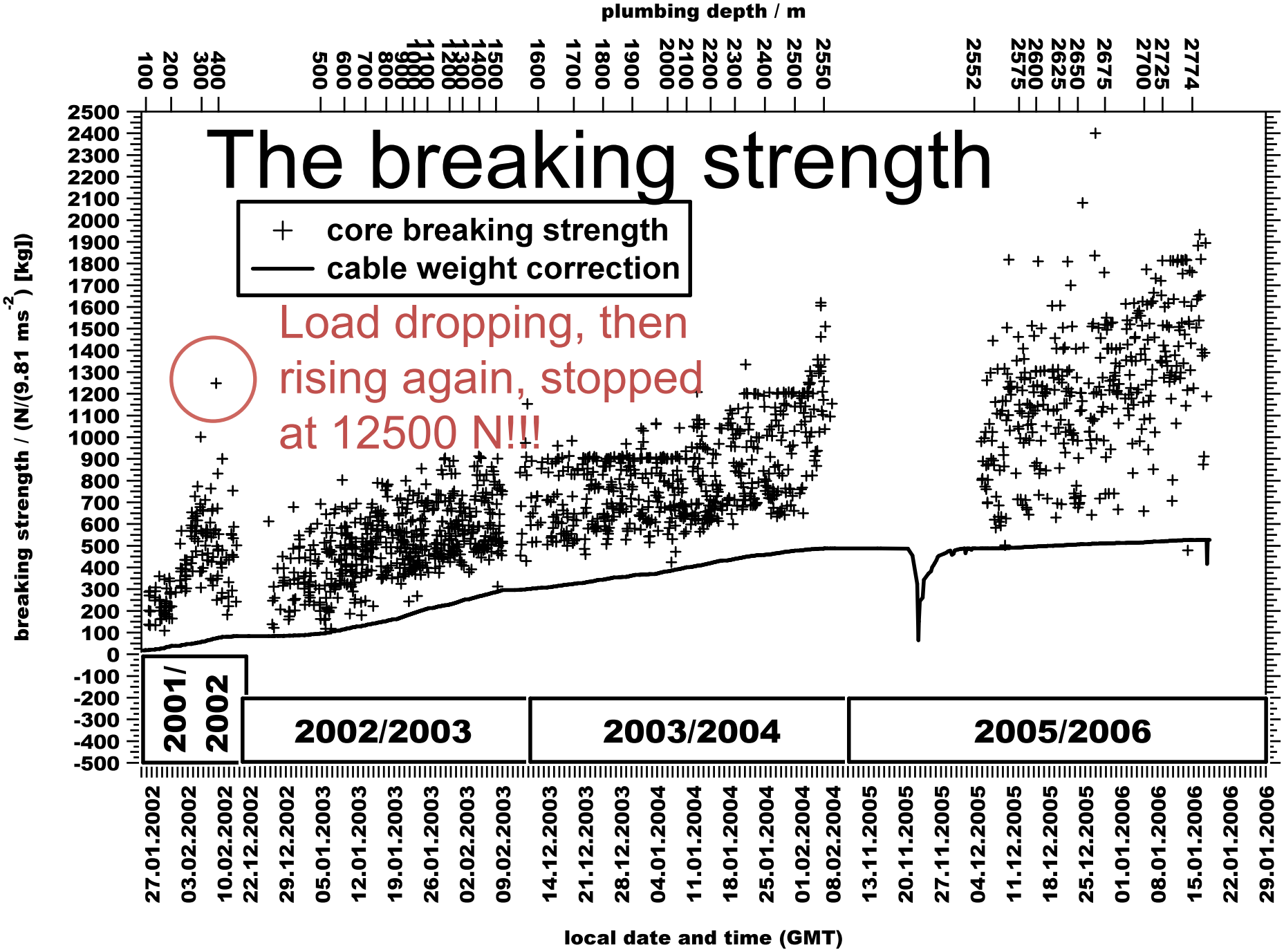
http://neem.nbi.ku.dk/about_neem/drillingicecores/

Still some hard breaks



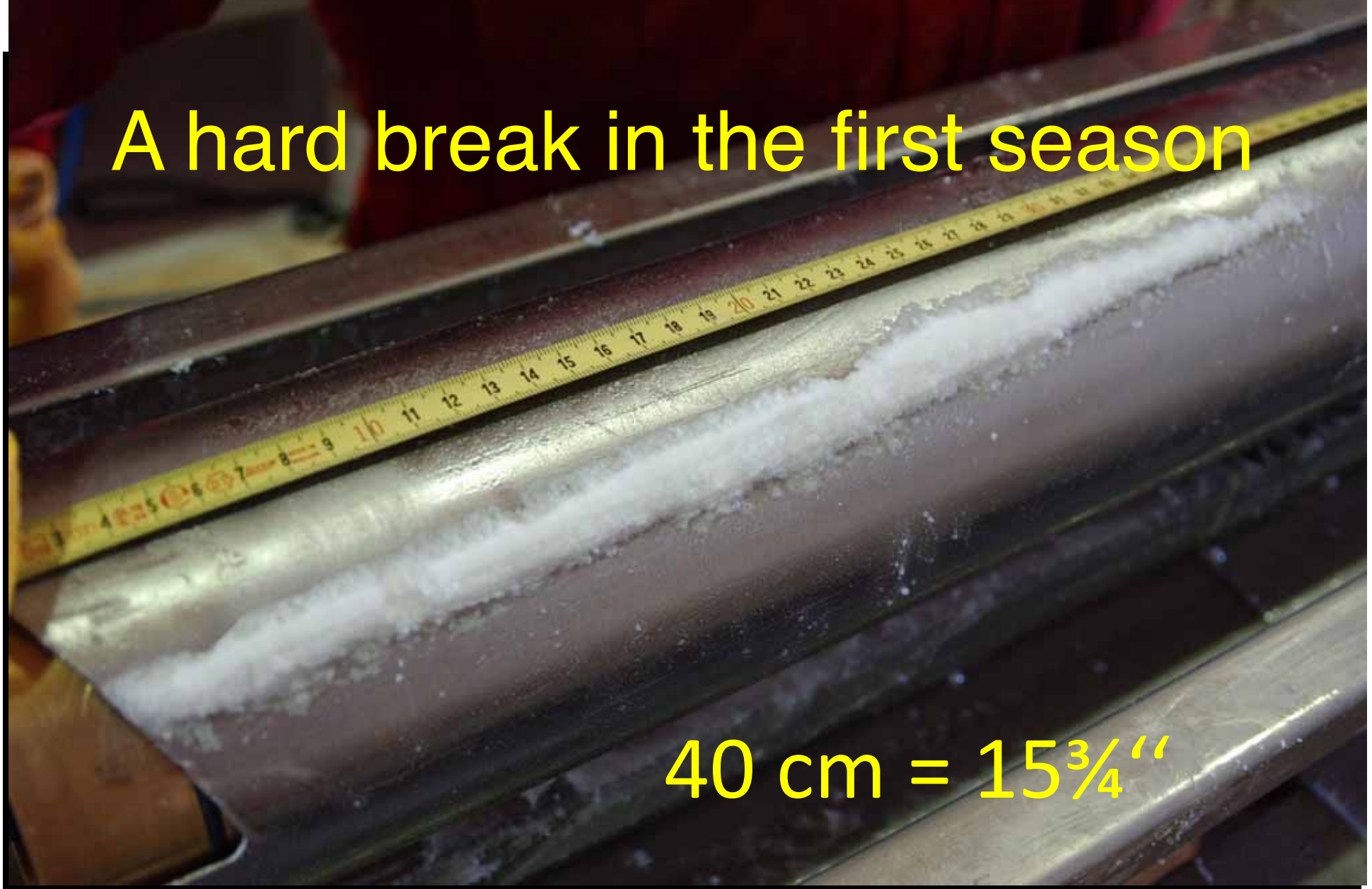
Base Kohnen (75°S, 0°E)




plumbing depth / m
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2550 2552 2575 2600 2625 2650 2675 2700 2725 2774
The breaking strength
core breaking strength
cable weight correction
Load dropping, then rising again, stopped at 12500 N!!!
breaking strength / (N/(9.81 ms^{-2})) [kg]
2500 2400 2300 2200 2100 2000 1900 1800 1700 1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 100 0 -100 -200 -300 -400 -500
2001/2002
2002/2003
2003/2004
2005/2006
27.01.2002 03.02.2002 10.02.2002 22.12.2002 29.12.2002 05.01.2003 12.01.2003 19.01.2003 26.01.2003 02.02.2003 09.02.2003 14.12.2003 21.12.2003 28.12.2003 04.01.2004 11.01.2004 18.01.2004 25.01.2004 01.02.2004 08.02.2004 13.11.2005 20.11.2005 27.11.2005 04.12.2005 11.12.2005 18.12.2005 25.12.2005 01.01.2006 08.01.2006 15.01.2006 22.01.2006 29.01.2006
local date and time (GMT)

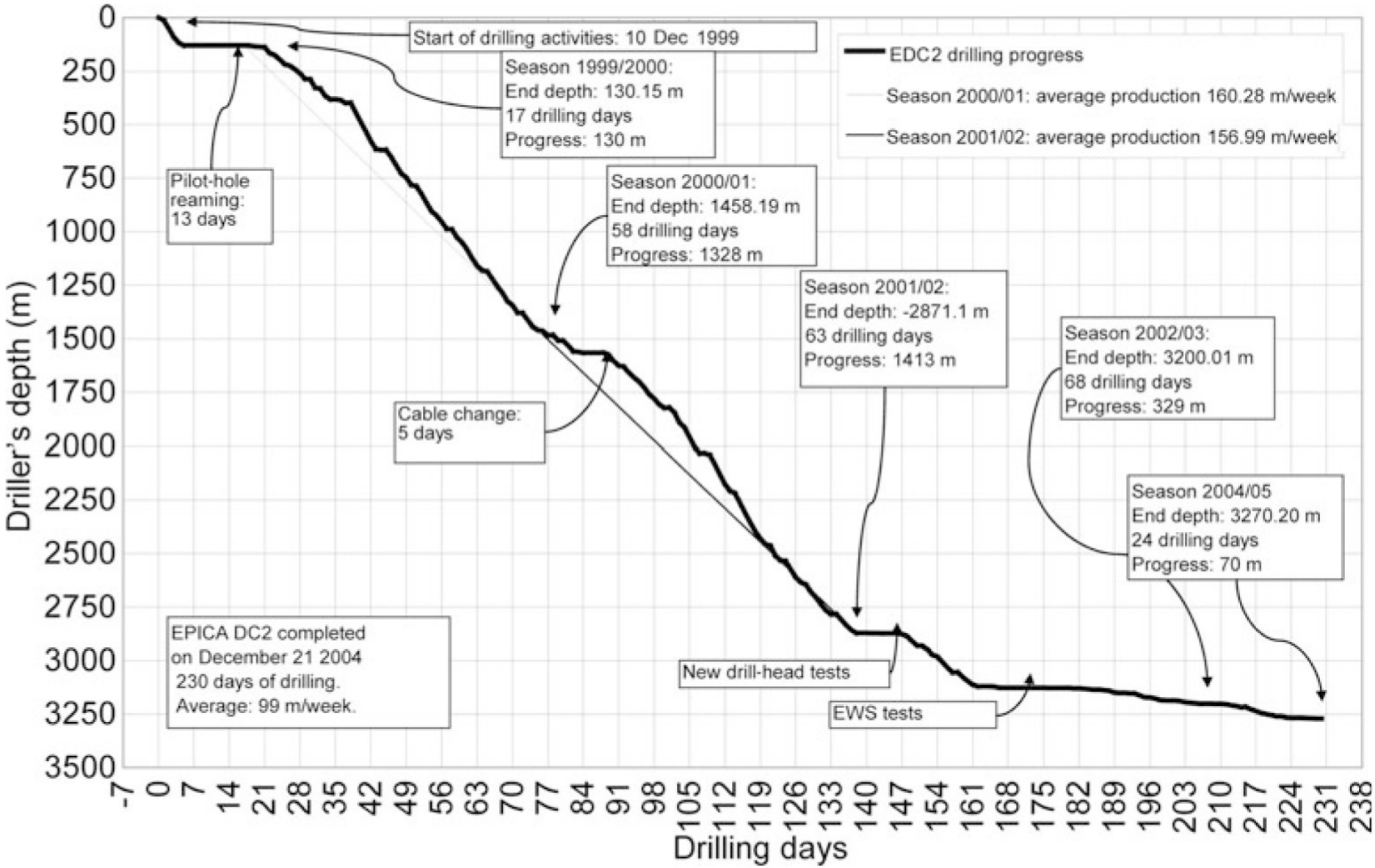
What had happened?

- It was drilled in the usual mode: Stop when power rises
- This one was pressing it very far, the cable load had dropped by 30-40 kg.
- Decision to idle (pump) for some time and then pull up
- Moderate core-break
- When pulling further load came up, stopped it at 12500 N
- Went forth and back, finally put load and rotated
- Got free some time

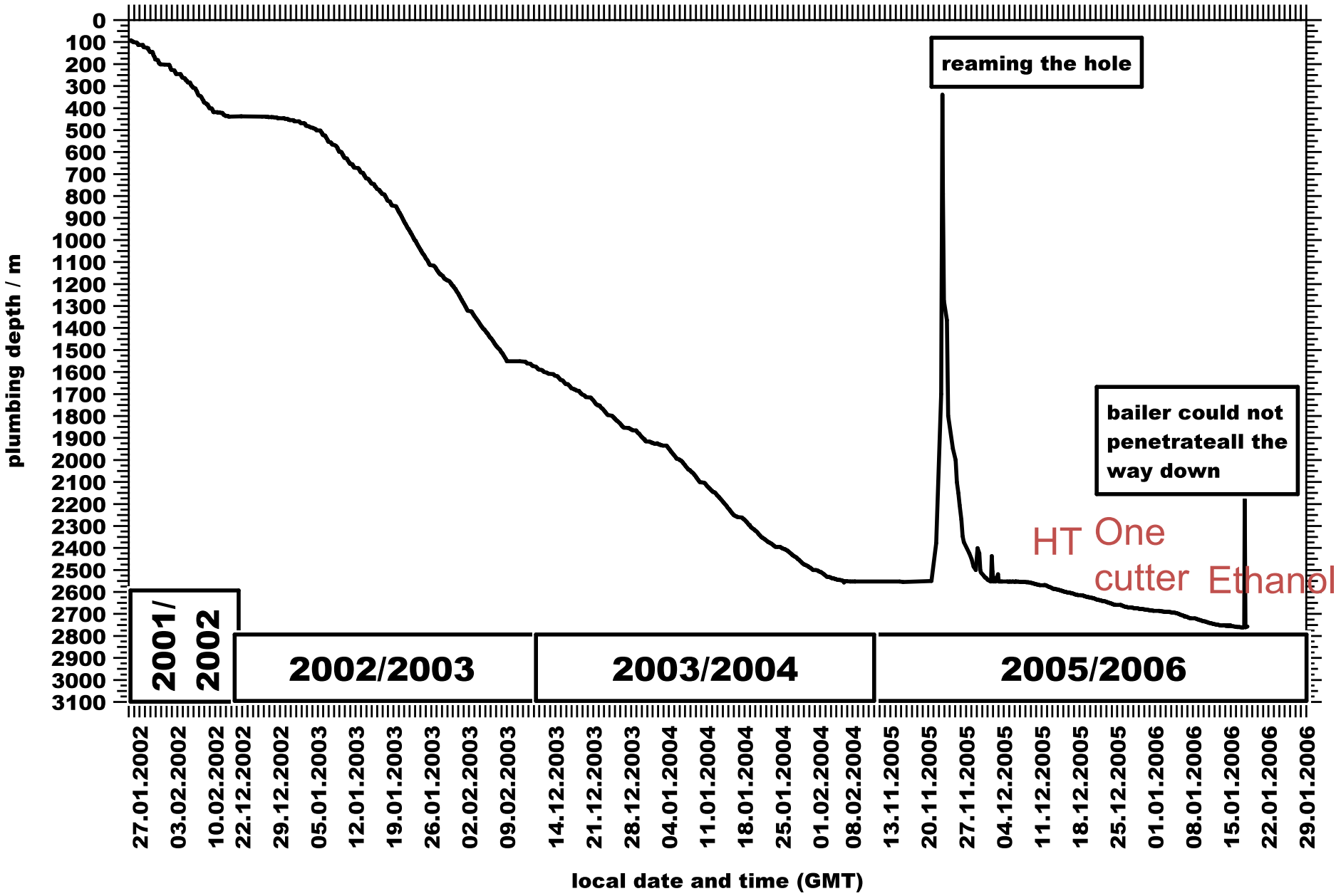


Very hard scraping with screw driver, no other chance!!!

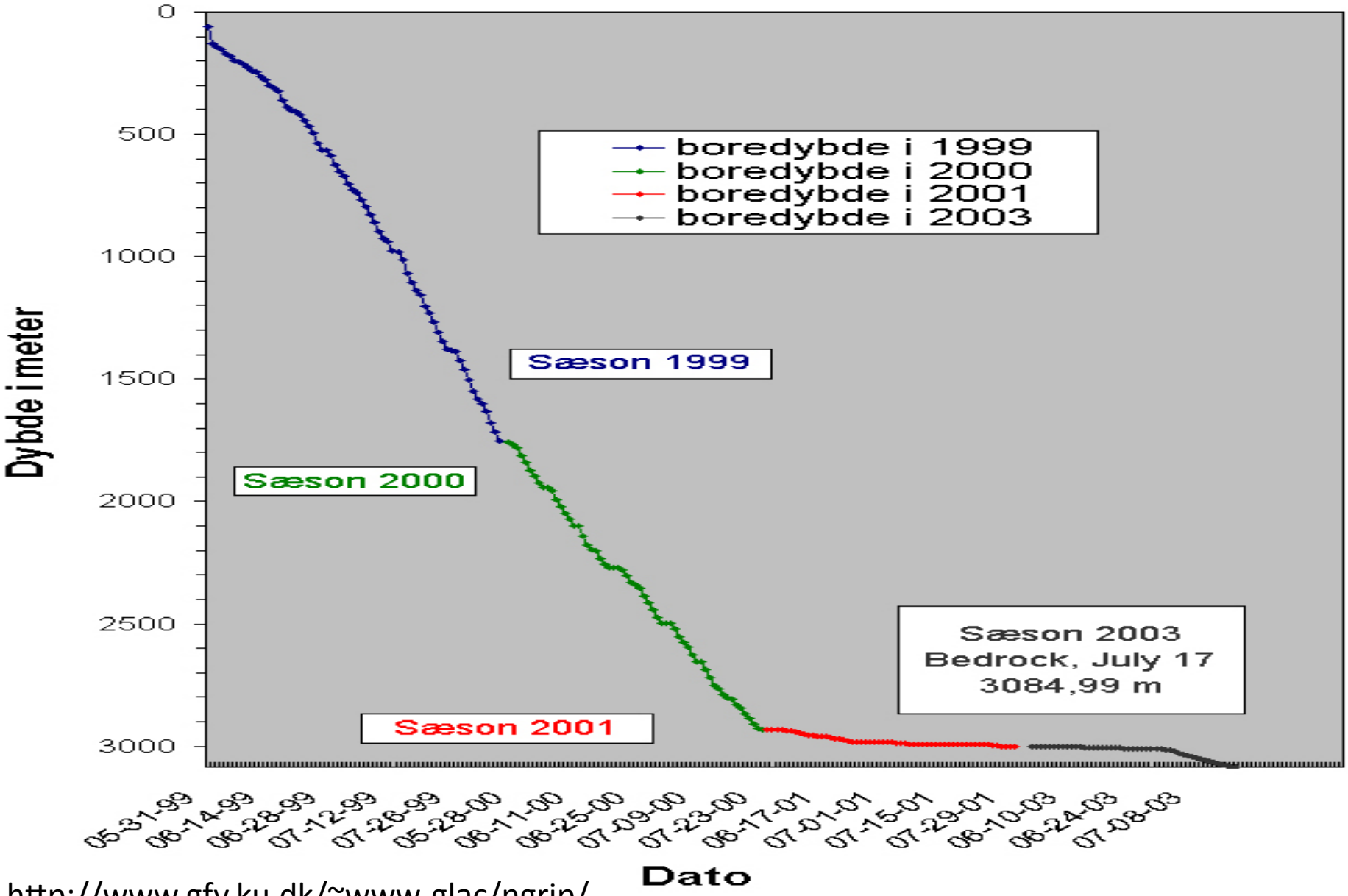
Penetration at EDC



Penetration at EDML

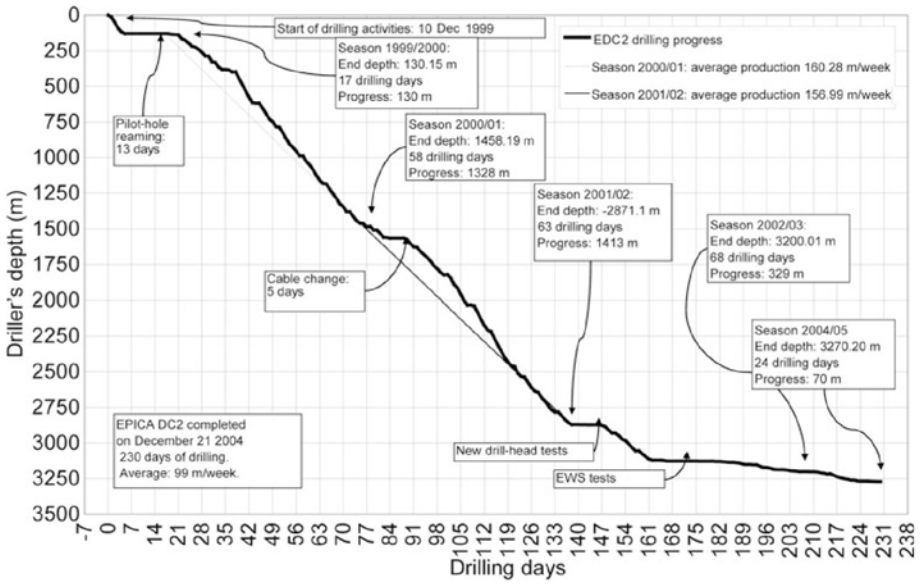


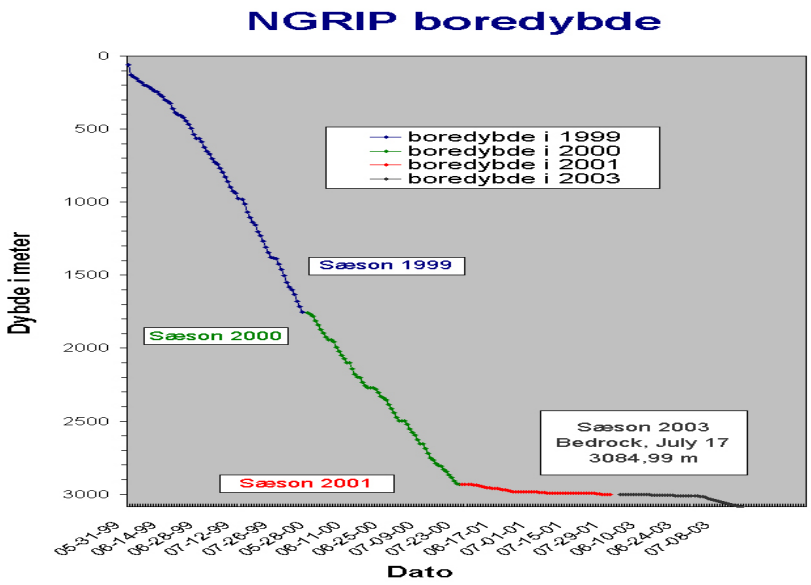
Penetration at NGRIP

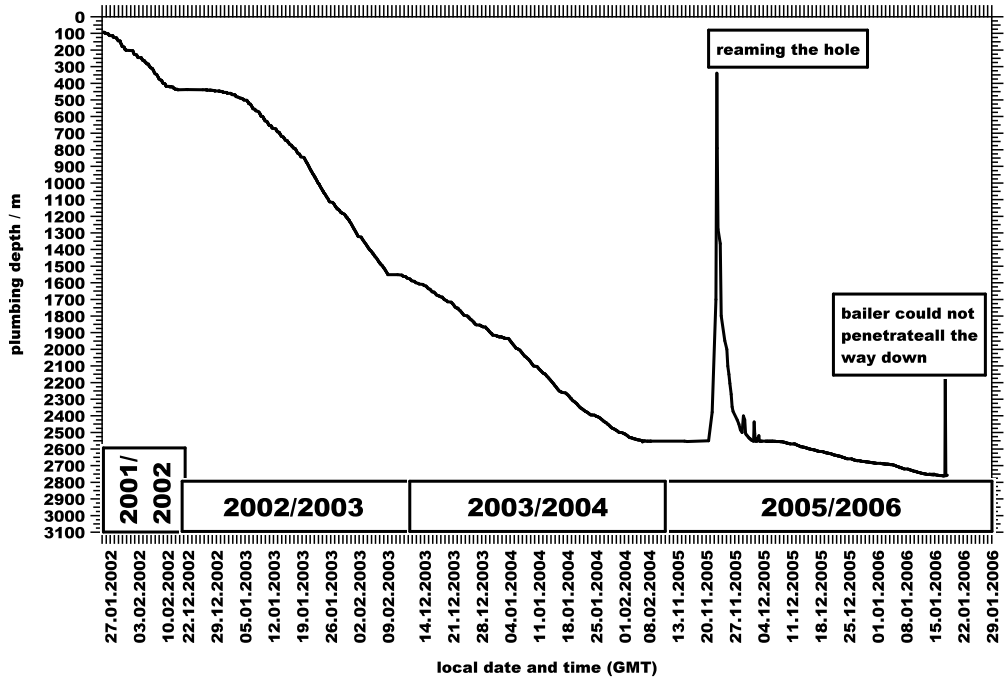


http://www.gfy.ku.dk/~www-glac/ngrip/

Penetration







The warm ice problems

Annals of Glaciology 47 2007

Heat generated by cutting ice in deep ice-core drilling

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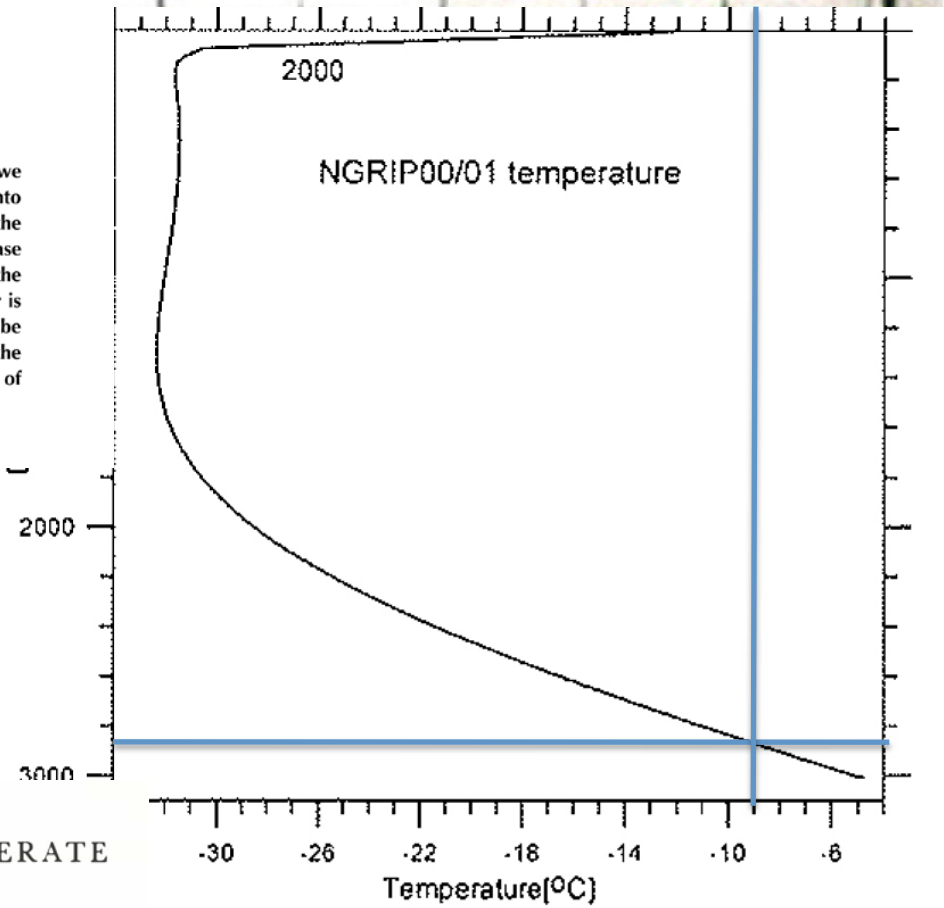
E-mail: azuma@mech.nagaokaut.ac.jp
[2]*National Institute of Polar Research, Kaga 1-9-10, Itabashi-ku, Tokyo 173-8515, Japan*

ABSTRACT. In order to understand and solve the 'warm-ice problem' in deep ice-core drilling, we applied the metal-cutting theory to ice and estimated the heat generated during ice coring taking into account the mechanical and thermal properties of the ice and cutters. We found that (1) most of the heat in cutting is generated by shear deformation at the shear plane of ice, and the heat could increase the chip temperature by several degrees; (2) the rake angle of the cutter has more influence on the temperature increase in chips than the barrel rotation speed and penetration pitch; (3) if the cutter is made of a material with larger thermal conductivity, the temperature increase in the chips can be reduced; and (4) if the density of the liquid is less than the density of ice, the cutting chips sink to the bottom and the friction heat generated by the drill head and slush can raise the ambient temperature of the drill head by several degrees.



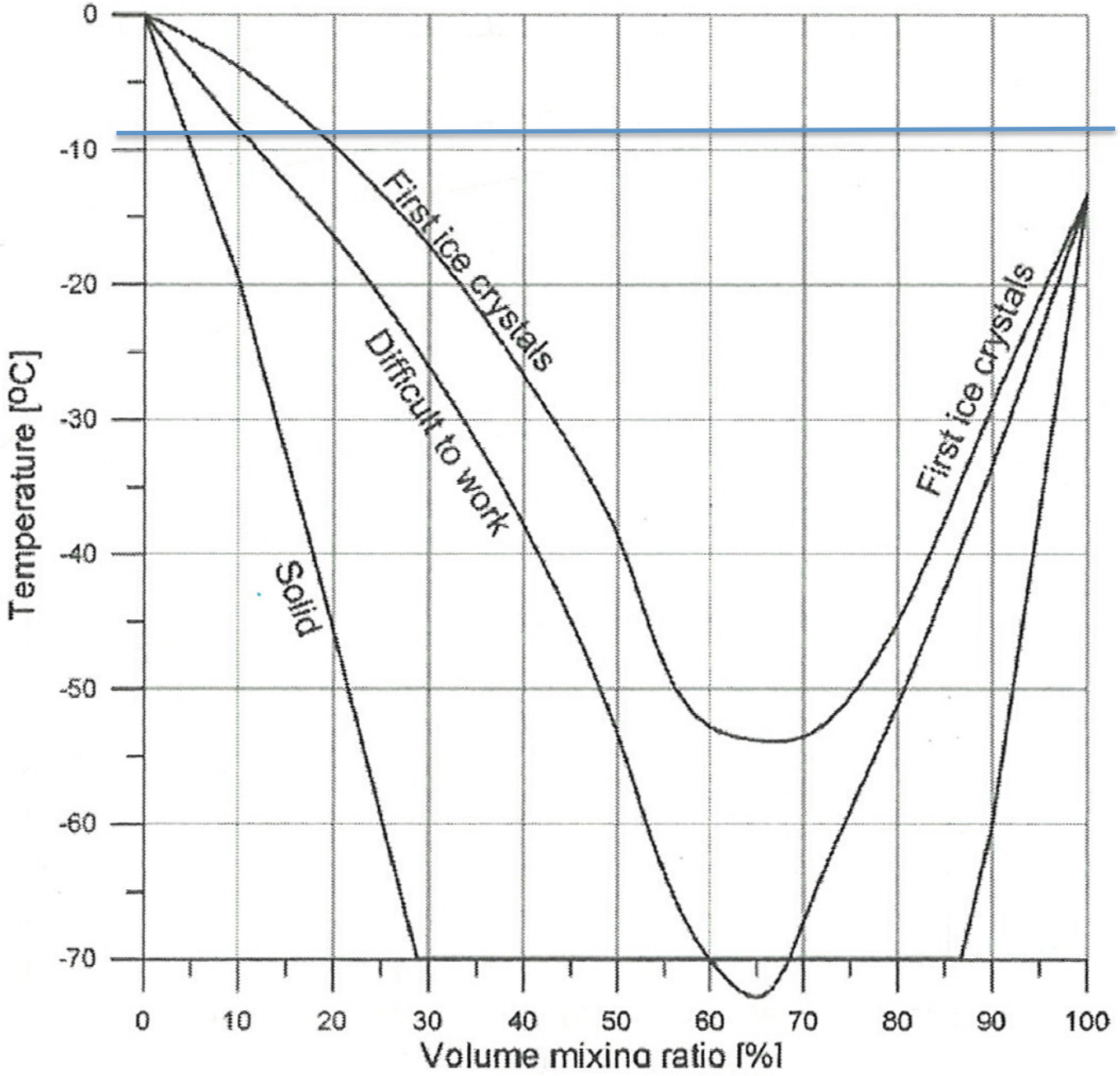
Journal of Glaciology, Vol. 13, No. 67, 1974

MECHANICAL DRILL FOR DEEP CORING IN TEMPERATE ICE

By Bragi Árnason, Helgi Björnsson *and* Páll Theodórsson
(Science Institute, University of Iceland, Reykjavík, Iceland)

Abstract. A rotary drill for deep coring in temperate ice has been constructed and tested. The total length of the drill is 6 m and its weight is 100 kg. A steel armoured cable carries power to the 2 h.p. electric motor of the drill. The diameter of the core is 90 mm and the maximum length of core is 2 m. An antifreeze mixture at the bottom of the hole was necessary to prevent refreezing of ice chips on the cutting bits.

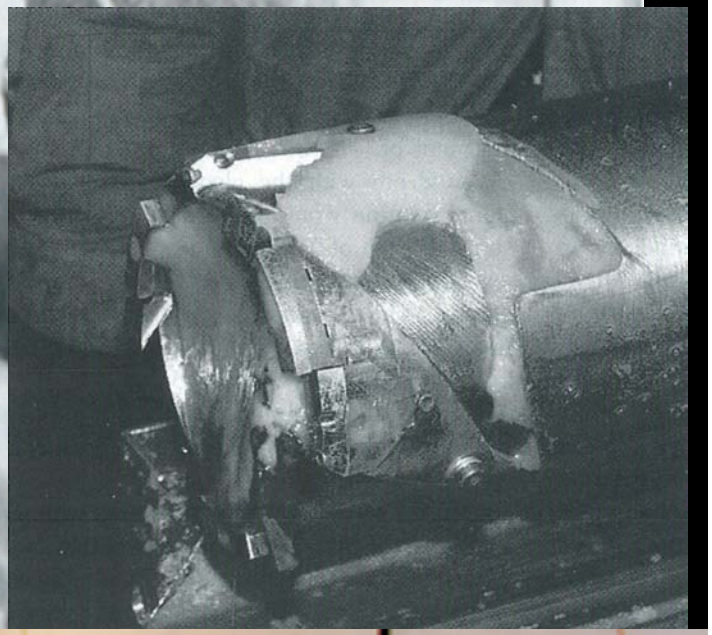
A 415 m deep hole was drilled during the summer of 1972 into the temperate accumulation area of Vatnajökull. Core recovery was 99%. Because of a fault in the cable the bottom was not reached.



Frozen glycol

Fig. 5. Freezing properties of a ethylene glycol / water mixture.

Glycol pellets



Sticking deep ice core drills: Why and how to recover

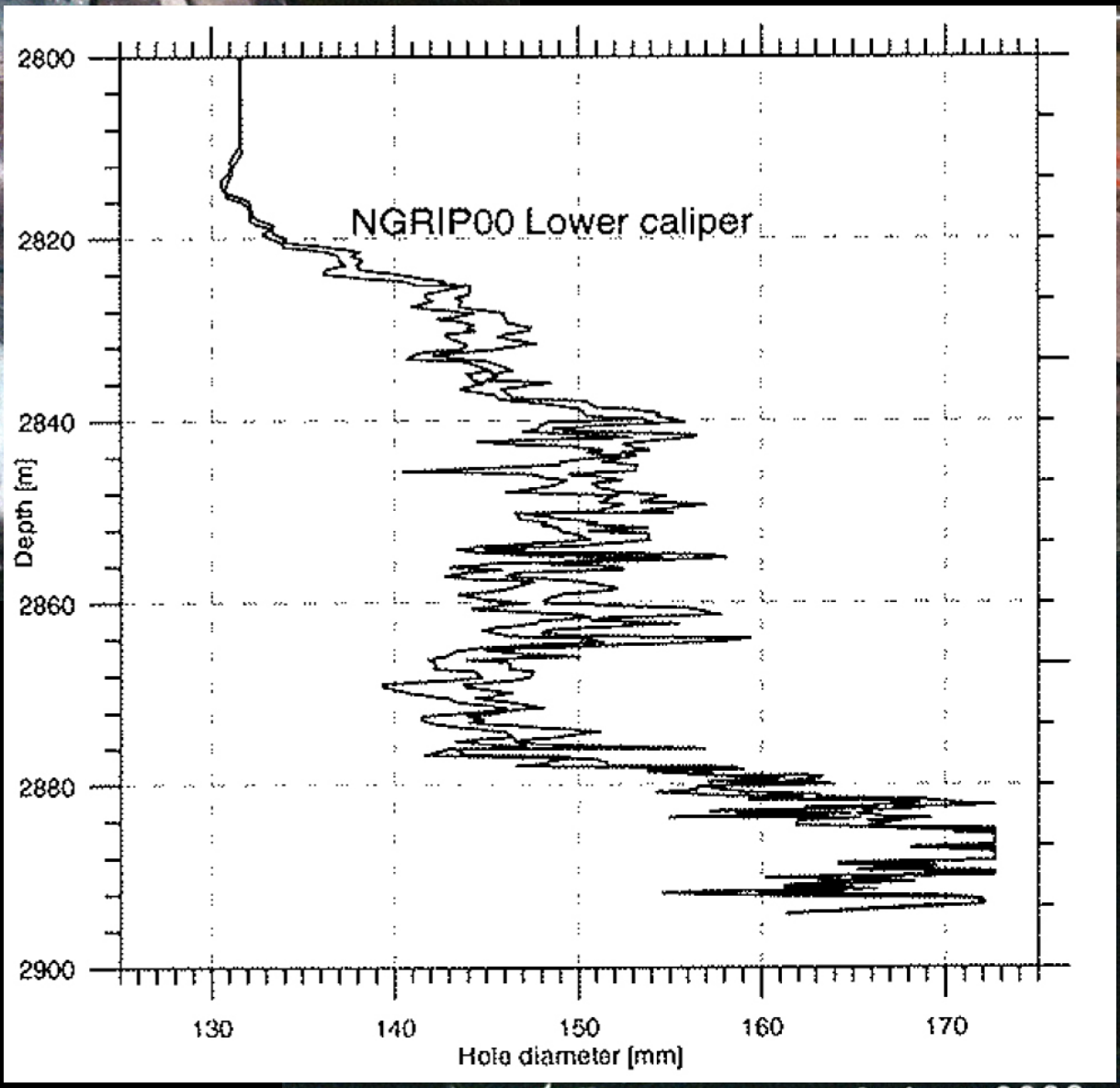
Niels S. Gundestrup[1], Sigfus J. Johnsen[1], Steffen B. Hansen[1], Hitoshi Shoji[2], Pavel Talalay[3] and Frank Wilhelms[4]

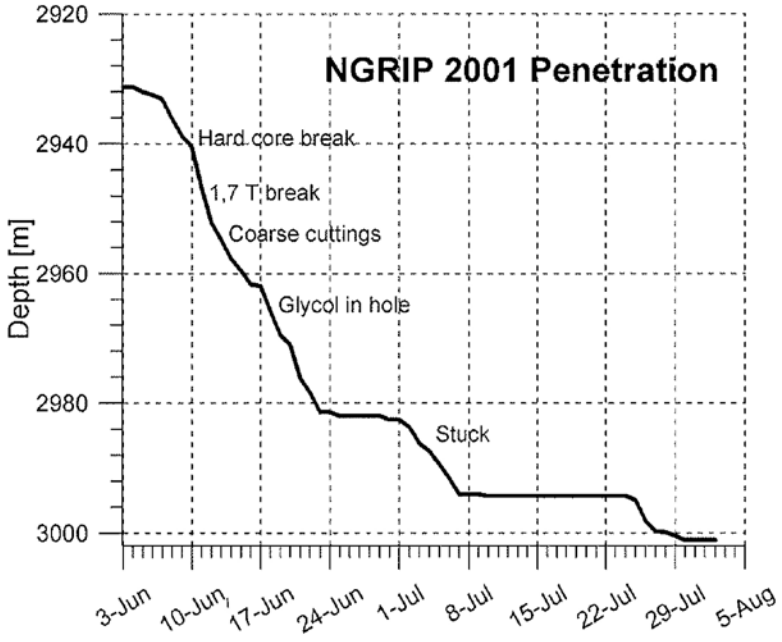
[1]*University of Copenhagen, Department of Geophysics, Juliane Maries Vej 30, DK-2100 Copenhagen OE, Denmark*
[2]*Kitami Institute of Technology, 165, Koencho, Kitami 090-8507*
[3]*Department of Descriptive Geometry, St. Petersburg State Mining Institute, 21 Line, 2, 199026 St. Petersburg, Russia*
[4]*AWI, Colombusstrasse, Bremerhaven, Germany*

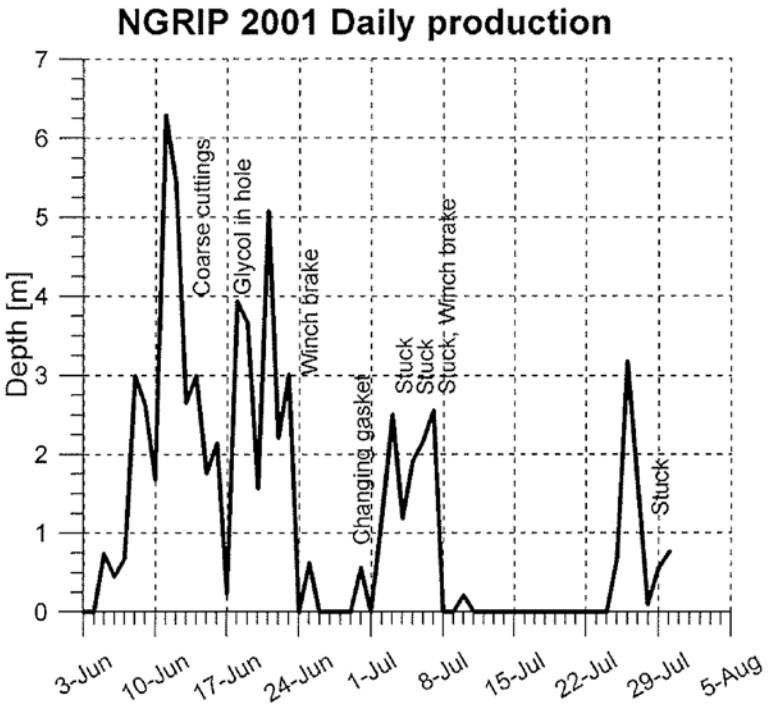
Abstract: The GISP deep drill became stuck in 1981, but was free the following year. The NGRIP/EPICA deep drill has suffered from two big setbacks: The drill is stuck both at NGRIP in Greenland and at Dome C in Antarctica. Both events occurred in a period with routine drilling and high productivity. The reasons for the two events are believed to be different, but the chosen bore-hole liquid seems to be problematic. The densifier can adhere to the surface of the ice cuttings, making fine ice cuttings to sink in the liquid, in spite of a liquid density of 935 kg/m^3.

In spite of changed procedures and modified constructions, the drill became stuck again at NGRIP. It was freed using glycol, making use of both the temperature and temperature gradient in the hole.

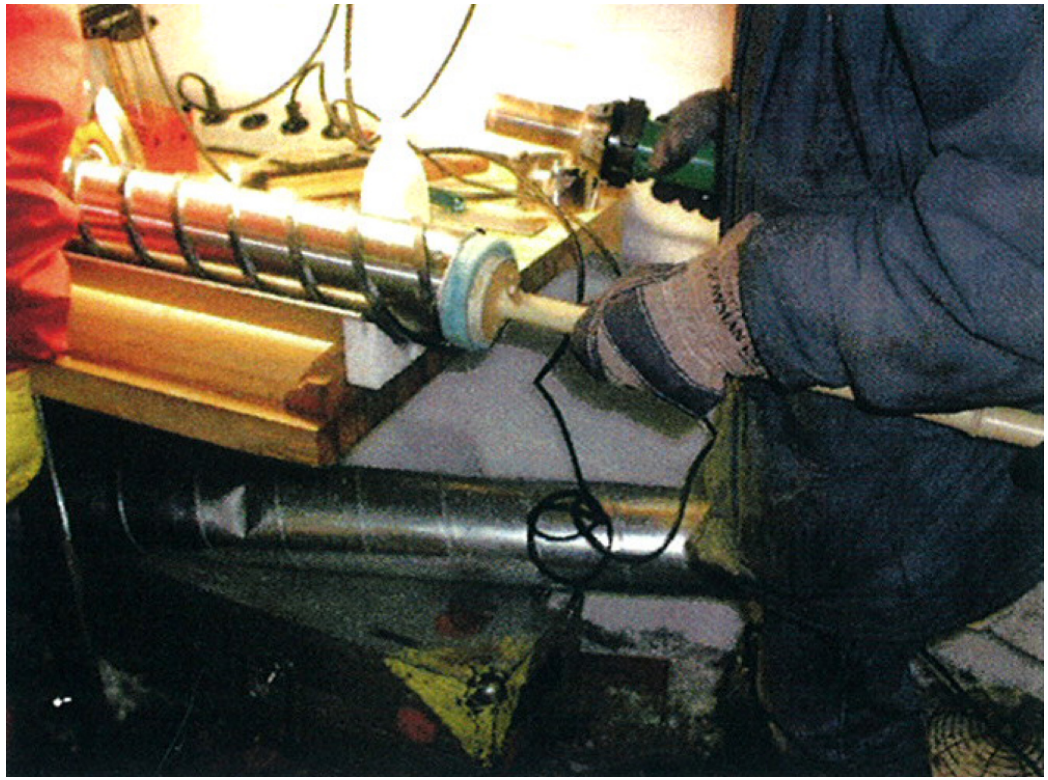
What technical glycol does



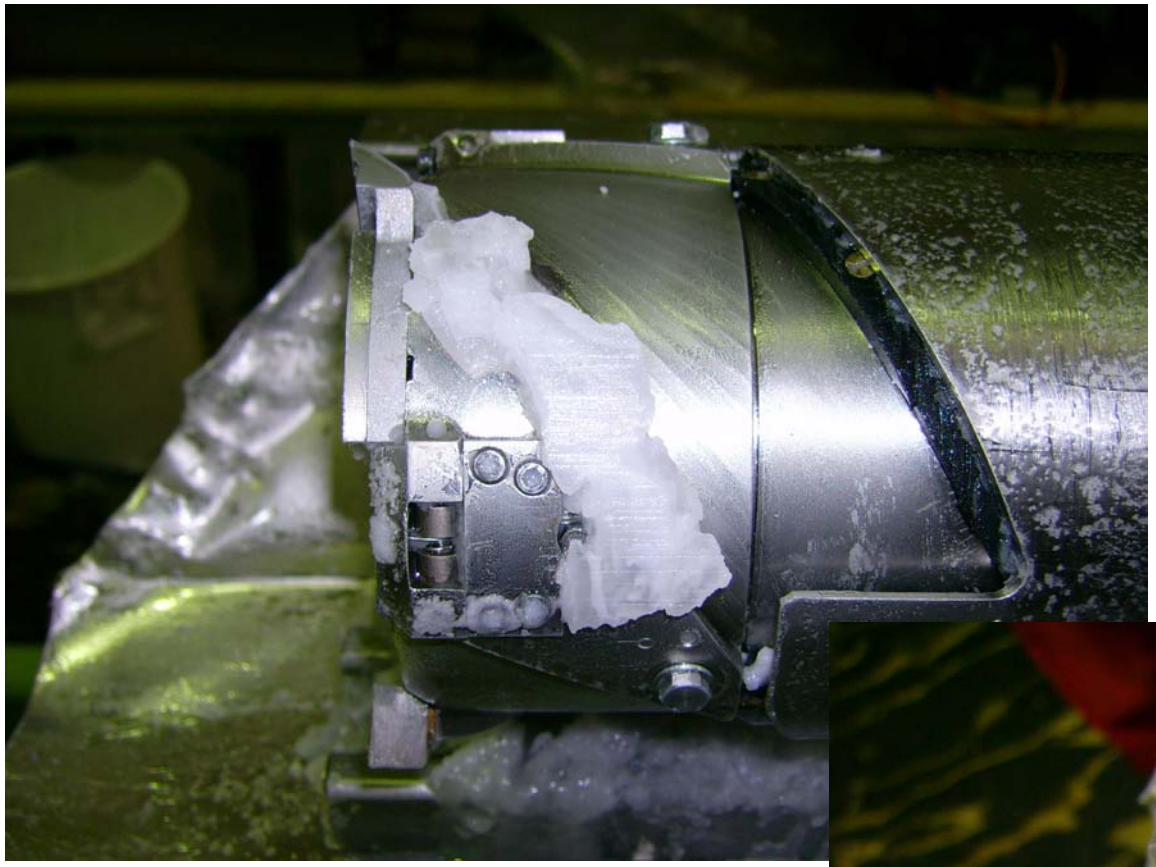




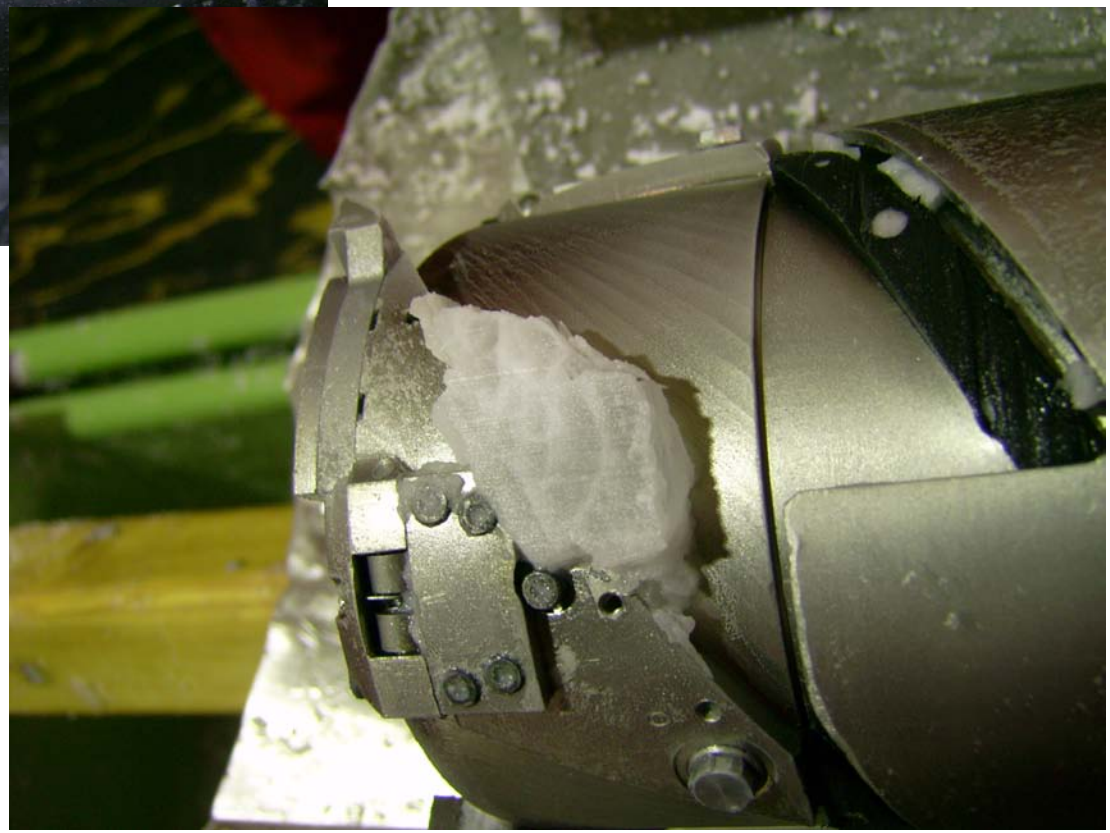
Live with the warm ice

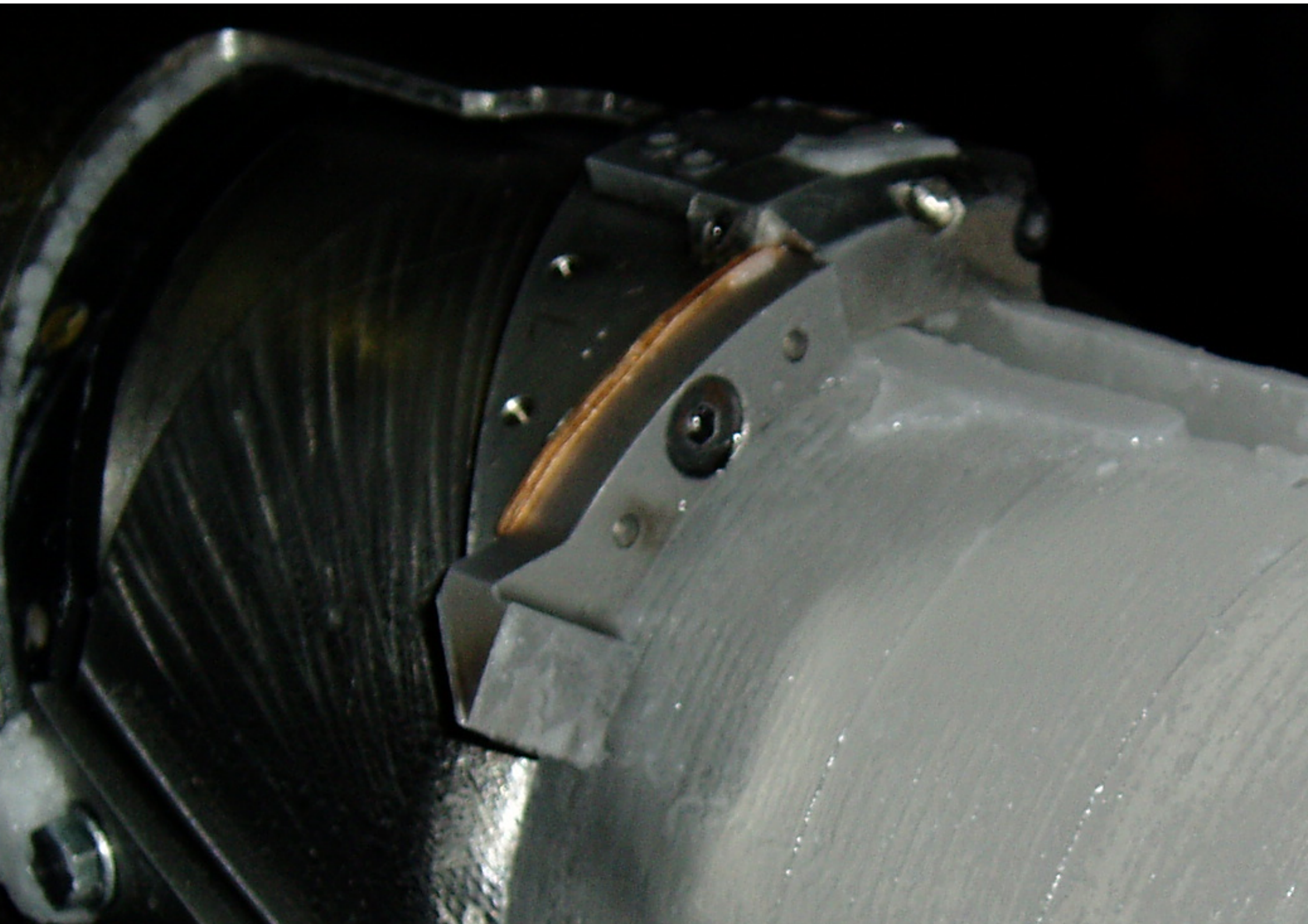



At the end of the 3rd season warm ice problems
• bad penetration
• core sticking in the barrel

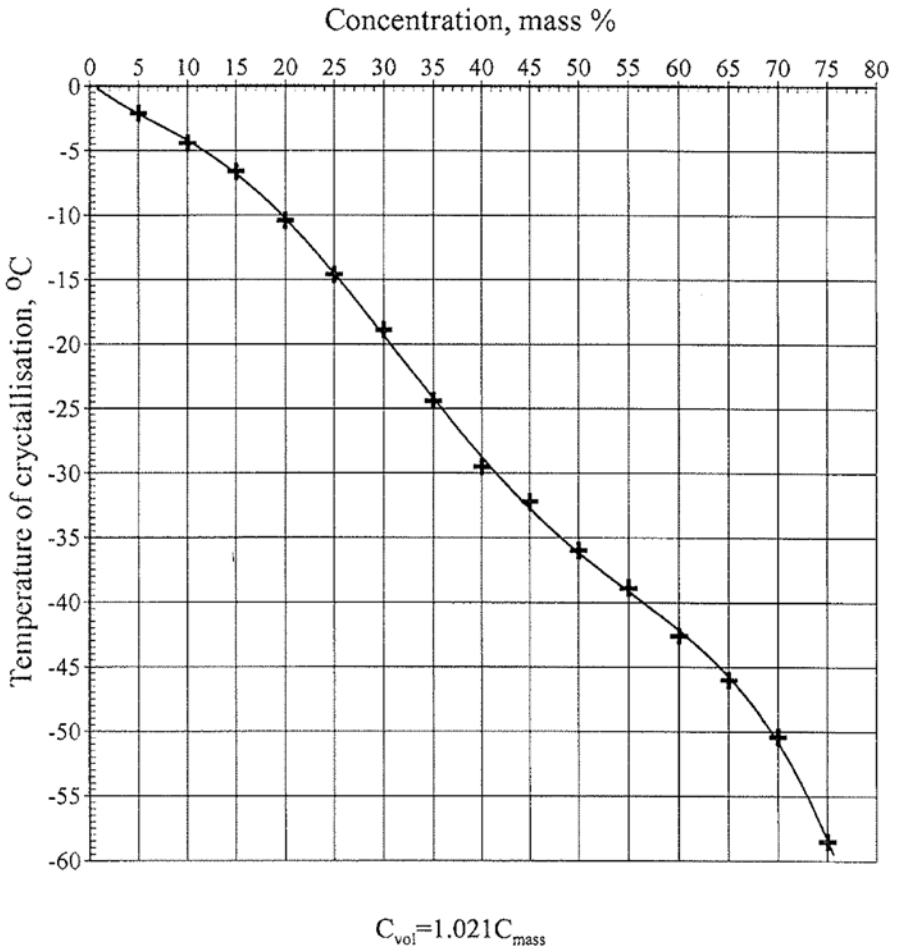


Icing Chips cannot enter barrel!!!





Refreezing on the drill


Concentration, mass %
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60
Temperature of cryctallisation, °C
$C_{vol}=1.021C_{mass}$
c:\victor\victor\ews\ews-t-crystall1.grf

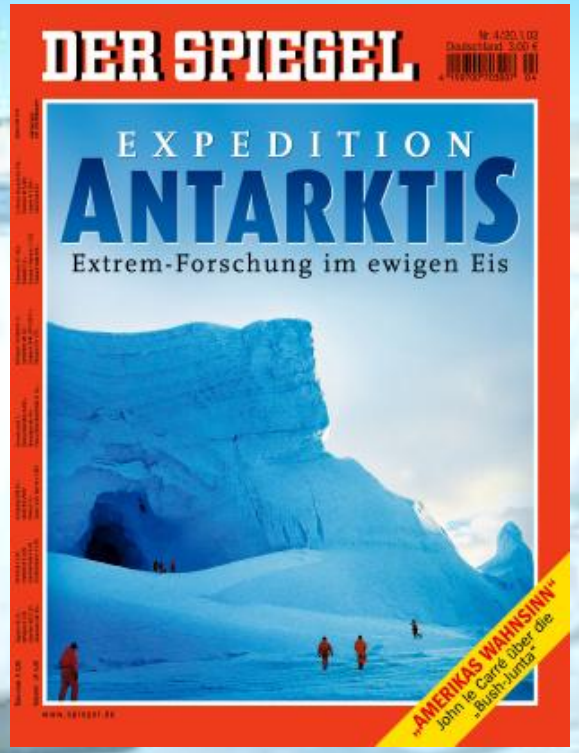
Cognac bomb

Ethanol Water Solutions:

WARM FLUID BATH

Bedrock

Icecore daddy & icecore mummy




Thank you Sigfús & Pála
EYE WASH STATION
© Dansgaard, Frozen Annals


Private
links
03. October 2010


Jacob‘s wedding
27. August 1988

Sorry for not bringing the crate this time